Scotland's Rural College

Estimation of a Hedonic Price Equation with Instruments for Chicken Meat in the UK: Does the Organic Attribute matter?

Gschwandtner, Adelina; Ribeiro, Jose Eduardo; Revoredo-Giha, C

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Abstract

Chicken meat consumption has increased substantially in the last decades due to farming and processing intensification and due to perceived health and environmental benefits for consumers. Organic chicken additionally, is perceived to have better taste, lead to higher animal welfare and additional benefits for the environment. Thus understanding consumers' preferences for organic chicken is central for policy-making and market strategies that can shape this market in the future. This paper uses a comprehensive data set of scanned shoppings from UK consumers, to show that they are willing to pay an average premium of 135% for the organic attribute in the case of chicken. In addition, this paper contributes to the literature of environmental valuation, demonstrating that household characteristics can be used as instruments into a GMM approach to a hedonic price model, to address the endogeneity issues usually ignored in this literature.

JEL classification: C26, Q18, Q51

Keywords: Hedonic Pricing Method, Instrumental Variables, Organic Food

1 Introduction

There has been a significant increase in breeding and consumption of chicken globally, altogether with a potential positive effect on consumers' diet (health) and reduced carbon footprint.[1] The rise in chicken consumption has driven large attention among consumers, producers and suppliers and, has been reflected in the media more recently (BBC, 2018; The Economist, 2019; The Guardian, 2018). The organic approach to food production adds to these potential benefits a perceived better taste, more environmentally friendly production and higher animal welfare. Thus, understanding consumer preferences for the organic attribute in chicken appears as a necessary step forward. This paper values the premium UK consumers actually pay for the organic attribute, and this information can be used in policy-making considerations, from social marketing (considering organic food as merit good) to the valuation of the right supply incentive to match local demand.

According to the OECD (2017) global consumption of chicken has grown 134 percent since 1990. The bird counts for 23bn of the 30bn land allocated to animals living in farms (Bennett et al., 2018). Intuitively, price is one of the main drivers of such an increase in consumption, as producers have been able to reduce average costs through methods such as selective breeding and as a consequence, reduce the price. Chickens are not only large in numbers, but have also grown in size. The average weight of a 56 days old chicken in 1957 was 0.9 kilograms, while in 2005 was 4.2 kilograms (Zuidhof et al., 2014). Chicken appears to be the most consumed meat in the world at this point, and this applies to the UK too, as shown in Figure **??** (Appendices). Because of this reason, it is useful to understand the contribution of each attribute to the willingness to pay for broiler chicken and especially the one of the organic attribute.

Ribeiro (2019) shows in his meta-analysis that on average organic products are considered to have a positive overall impact on individuals (especially health), the environment (soil, pollination and biodiversity protection), and animal welfare (humane farming).[2] These perceived benefits have been pivotal to the significant increase in the production and consumption of organic products worldwide. However, in the UK, the picture looks somewhat different. While sales were increasing, in-line with the global trend up to 2008, there was a noticeable dip after the 2008-2010 financial crisis (Figure **??**, Appendices). Despite 6 years of strong growth, sales are only just regaining their 2008 level, while organic farmland has decreased 5 percent per annum since 2011 in the country, as farmers are converting back to conventional production (Soil Association, 2018) potentially missing out important financial and environmental opportunities.

The present paper aims to estimate in a robust manner the premium consumers are willing to pay for the organic attribute in chicken meat. This is important for organic chicken farmers but also in order to appreciate the merits of any policy options related to consumption and production of organically farmed chicken in the UK. In order to do so the present study employs a hedonic price (HP) method using an instrumental variable approach where consumers characteristics are employed as instruments. HP is a revealed preference approach that uses information from actual behaviour of consumers, and shows how different product characteristics contribute to the price of the product. However, as discussed in the literature, the model suffers from econometric issues, which are often ignored in empirical work. Most notably the endogeneity of the product characteristics, which in the case of this study, includes the organic attribute. To address this issue, the present paper uses the generalised method of moments (GMM), using consumer characteristics as instruments. This is something that to our knowledge has not been done before and constitutes the main

[1] If consumers replaced red meat with chicken.

[2] There is a valid argument however, that organic agriculture has lower yields than conventional agriculture, and critiques argue that it would therefore need more land to produce the same amount of food resulting in more deforestation and biodiversity loss undermining the principle of environmentally friendly production (Seufert et al., 2012; Meemken and Qaim, 2018).

contribution of the paper.

The issue of endogeneity in HP models derived from the simultaneous estimation of supply and demand, has been first risen by Rosen (1974) in his seminal work. Despite of this, very few studies have tried to address it. Follain and Jimenez (1983) & Follain and Jimenez (1985) seem to be two of the few exceptions. Other studies that use instrumental variables in a hedonic price model are Combris et al. (1997) and Gopalakrishnan et al. (2011). However, these two studies do not address the original endogeneity problem discussed by Rosen (1974). Combris et al. (1997) analyze the importance of the attribute 'Quality' in the determination of the price of Bordeaux wine and use instruments to address the endogeneity between the length of the jury reports and the quality of the wine assessed by these reports. Gopalakrishnan et al. (2011) estimate the value of beach width capitalized in the values of properties situated close to those beaches using instruments to address the endogeneity between the two. Properties close to beaches with a larger width have higher prices but beaches close to properties with higher values tend to be broader due to more frequent beach nourishment programs that combat erosion. Both these studies address endogeneity caused by reversed causation and find that instrumenting has a significant impact on the results. Nevertheless, most HP studies do not address the endogeneity issue at all. Kahn and Lang (1988) and Wooldridge (1996) are two of the few exceptions that addresses it both from a theoretical and empirical point of view and suggest how instruments can be used to solve it (Kahn and Lang, 1988 in a 3SLS and Wooldridge, 1996 in a GMM setting). However, the main focus of these two papers is the econometric theory and not the empirical applications. In the present case the robust estimation of the premium for the organic attribute of chicken in the UK is essential. Some of the papers mentioned here will be discussed in more detail in the next section when explaining the instrumental strategy which constitutes the main novelty of the present paper.

The present paper contributes to the environmental valuation literature, by comparing results obtained with OLS and 2SLS with the ones obtained with GMM - the method that is considered to be most appropriated for an instrumental variable approach in a hedonic pricing setting according to Wooldridge (1996). The results show that ordinary least square (OLS) is potentially underestimating the contribution of the specific attributes while 2SLS appears to overestimate it when applied in the hedonic pricing setting. This is relevant as HP is widely accepted for its reliance on actual market prices, whilst alternative stated models from surveys and experiments are often criticized for their hypothetical nature. The present paper shows how the simultaneity of the marginal price and quantity of attributes implies that the product characteristics are potentially endogenous. It illustrates that GMM offers a reliable solution to this endogeneity problem and appears to be more appropriate not only than OLS but also than 2SLS. In line with Wooldridge (1996), this study suggests that, whenever applicable, consumer attributes can form a suitable source of instruments to address the endogeneneity problem of product characteristics. In the present case, the contribution of the organic attribute to the price of chicken meat was treated with instruments generated from family structure of respondents that passed the required statistical tests. Using this strategy, the present paper estimates a premium of 135 percent for the organic attribute of chicken meat in the UK.

Additionally, the present results also offer insights about the heterogeneity of organic premia across chicken parts and the UK regions.

The paper is structured as follows: section 2 describes the theoretical background and the issue of endogeneity in HP models. Section 3 describes the data used. Section 4 presents the empirical results and section 5 concludes.

2 Theoretical background

This chapter applies the hedonic price model in order to estimate the contribution of attributes associated with organic chicken, considering consumers' perception that such a product offers better results in terms of the environment, human health, and animal welfare, and potentially quality and taste (Wier et al.2008, Grifth and Nesheim 2008, Aertsens 2009, Gschwandtner 2018). The HP model is one of the most popular revealed preferences approach to environmental valuation. It is widely used to estimate the added value of housing attributes, e.g. environmental amenities, but also has been applied to markets in the food industry, including dairy, produce, and eggs (Griffith and Nesheim, 2010; Kolodinsky, 2008; Schollenberg, 2012; and many others). The method is derived from consumer theory, based on the assumption that a consumer's utility for a good or service is driven by the attributes associated with it (Garrod et al., 1999). The theoretical framework of the hedonic method was proposed by Rosen (1974), which applied his model to a commodity with many characteristics.

The method, however, whilst widely used, is often applied ignoring its econometric issues, notably the simultaneity problems derived either from supply and demand equilibrium or marginal price and quantity of attributes, the latter being associated with the non-linear characteristics of the price function, as illustrated by Follain and Jimenez (1985), Wooldridge (1996), Bishop and Timmins (2011), and others.

In this section, it will be argued that in the present case, the supply and demand simultaneity is not a problem, thus there is no need to incorporate supply-side information. Instead, the second simultaneity problem derived from the non-linear nature of the price function has to be addressed.

Starting with the two-steps baseline hedonic price model proposed by Rosen (1974) for a product with characteristics z, where $z = (z_1, \ldots, z_n)$, the approach involves estimating the hedonic price from equation (1), then supply and demand functions. In the first step, the marginal price of z, given as $(p(z))$, is estimated using the best fitting function form by OLS. This would involve regressing observed differentiated product prices on their characteristics (z) and other characteristics related to consumers or suppliers, e.g. geographical location, that may influence prices, given as x^h. The price function is defined as a function of its characteristics z_i, x^h and the stochastic error term ϵ, given as:

$$P = f(z_i, x^h, \epsilon) \tag{1}$$

From the results, one can compute the marginal implicit prices $p(z)$ (the marginal price of z) for each buyer and seller. In Rosen's second step, the marginal implicit prices of each entry are used as an exogenous variable in both demand and supply functions. It is important to stress that firms and households are assumed to be price-takers, thus p is defined by the market clearing conditions, i.e. market equilibrium. It is also realistic to assume that equation (1) is non-linear. We will come back to these assumptions and their implications later. Meanwhile, the utility function is given by:

$$u = u(x, z)$$

Where x is a unity price composite commodity. The budget constraint posed to consumers would, given income y, then be $y=p(z)+x$.

The first order condition (the marginal effect of attributes z on price) entails:

$$\frac{\partial p}{\partial z_i} \equiv p_i = u_{zi}/u_x, i = 1, ..., n$$

While the amount consumers are willing to pay for characteristic z is given by the function:

$$\omega(z, u, y, \alpha)$$

Given their utility and income:

$$u = u(y - \omega, z, \alpha)$$

Where α is a taste parameter (differs across individuals). Therefore, the amount individuals are willing to pay for the characteristic z_i is given by:

$$\omega_i = u_z/u_x \tag{2}$$

As *p(z)* is assumed to be given, it represents the minimum price consumers are willing to pay to maximise their utility, i.e. only individuals who have a willingness to pay (wtp) above or equal to the equilibrium price would consume the good. This reveals that their lower bound wtp, i.e. *p(z)* is the minimum price the consumer must pay in the market. The utility is maximised at tangent point[3], where:

$$\omega(z^*, u^*, y^*, \alpha) = p(z^*) \tag{3}$$

* indicating optimum quantities.

It is important to note that $p(z^*)$ is also determined by supply. Thus, assuming firms are also price-takers, and profit maximisers, they are willing to accept a value ϕ, subject to the potential profit π and its cost structure c(z,β), where β indicates the factor prices and production parameters. Thus, the firm's willingness to accept (wta) is given by:

$$\phi(z^*, \pi^*, \beta) = p(z^*) \tag{4}$$

The fact that the equilibrium price $p(z^*)$ is simultaneously defined by demand and supply poses some econometric issues. In the hedonic pricing sorting, the product characteristics z are identified to be endogenous. The second possible source of endogeneity comes from simultaneity of z and $p(z)$. As the price function is likely to be non-linear, when individuals maximise their utility, both attributes z and $p(z)$ affect their choices simultaneously. Therefore, either way z needs to be instrumented.

2.1 Hedonic price regression models

Kantar Worldpanel is a comprehensive panel-scanner dataset containing a substantial number of available variables which are expected to explain the variation in price. We are working with data that is representative of Great Britain's purchases (Northern Ireland data are not collected) and use all the recorded transactions of 2016. However, consumer characteristics are usually not taken into consideration in the main hedonic model, as previously discussed. In addition, consumers are assumed to be price-takers and their characteristics should not be able to change the price available to them in most cases. As explained in above, following Rosen (1974), most studies focus on the characteristics of the product (z). Considering z as the vector of all product characteristics (mostly discrete elements, e.g. chicken part, organic, retailer, etc.), the model

[3]Assuming consumers' indifference curves are convex, i.e. we should expect that higher income always increases maximum attainable utility (Rosen, 1974)

includes dummies for special offer (γ_{i_t}) and region (η_r), and a vector for the month (δ_t).

Therefore, the household maximises utility by choosing a product with price p explained by:

$$ln(p_{irst}) = \alpha_1\delta_t + \alpha_2\gamma_{it} + \alpha_3\eta_r + \beta z_{is} + \epsilon_{irst} \tag{5}$$

Where: i, r, s and t are, respectively, item, region, store and time, and ϵ is the error term. Thus, δ varies with time, γ varies with item and time, η with region, and are specific to each item and store. The vector of characteristics allows to calculate utility by taking into account all of the information given, rather than looking at things one at a time. It is important to mention that t, in this case, will mostly explain seasonal variations, rather than capture wider shocks. For the latter, a larger annual panel data study would be required.

The appropriate functional form for hedonic method depends on the nature of the data used in the study. The predominant form used in the literature is the log-linear, but double-log is also used, as it facilitates the interpretation of results (Martínez-Garmendia, 2010 and Kim and Chung, 2011). Given that all explanatory variables are dichotomous, this study uses a semi-log function. The functional form will be applied in an OLS setting (model 1), in the first stage of the 2SLS (model 2) and in the GMM estimations (model 3). The last two attempt to address any bias from the simultaneity problem explained in section 2.2 (non-linearity), using socio-economic characteristics as instruments. As justified in section 2, the GMM estimation will be the main approach used in the estimations due to its ability to address endogeneity and heteroskedasticity, thus it will be the main source of results discussion.

The extended version of the model in equation (7) using GMM can be expressed as:

$$\begin{aligned} lnP_{irst} = \exp(&\beta_0 + \beta_1 Organic_{it} + \beta_2 FreedomFood_{it} + \beta_3 Offer_{it} + \beta_4 Branded_{it} \\ &+ \beta_5 BudgetLabel_{it} + \beta_6 Halal_{it} + \beta_7 Healthy_{it} + \sum_{j=2}^{7} \beta_j ChickenPart_{ijt} + \sum_{k=2}^{5} \beta_k Size \\ &+ \sum_{l=2}^{13} \beta_l Retailer_{ilt} + \sum_{m=2}^{7} \beta_m Region_{imt} + \sum_{n=2}^{12} \beta_n Month_{int} + \epsilon_{irst}) \end{aligned} \tag{6}$$

Where, in addition to the variables previously described, Organic represents organic label, Freedomfood represents the label for freedom food, Offer denotes any type of promotion, and Branded and BudgetLabel indicate external and own *low* price labels, respectively. Quality indicates products advertised as with superior quality (e.g. Tesco Finest, Asda Extra Special, etc.), Halal indicates halal chicken, and Healthy denotes the presence of a health label. From the remaining five types of dummy variables included in the model ChickenPart indicates the part sold (or whole chicken), Size indicates the package weight, Retailer the shop/supermarket (from 13 main companies), Region denotes the UK region, and Month represent the monthly dummies.

The exponential GMM format is widely used in applied work as alternative to linear regressions when the dependent variable uses log-transformed values. This avoids transformations from the original format for predicted values (Baum et al., 2003).

2.2 Choice of instruments

In the hedonic price literature there have been some few applications of instrumental variables approach to estimate coefficients of attributes of interest. Follain and Jimenez (1983) use as instruments predicted values of household income and household size, hence consumer characteristics. Gopalakrishnan et al. (2011) used spatial varying coastal geological features as instrument to estimate the amenity value of beach width, to coastal properties in a 2SLS estimation. Combris et al. (1997) have used sensory variables as instruments in a hedonic price estimation of attributes (notably, quality) of Bordeaux wine. All these studies have revealed a significant effect from the instrumental variables, despite the different endogeneity addressed across studies. The present paper uses socio-economic characteristics of households as instruments to treat the organic characteristic of chicken meat, as the variable of interest. For the socio-economic characteristics to be valid instruments, they have to be both exogenous and be relevant to the choice of the treated attribute.

There are a number of studies that confirm that socio-economic characteristics are relevant to organic food consumption, i.e. socio-economic characteristics drive the wtp for organic food. Griffith and Nesheim (2010) explore heterogeneity wtp for organic products across different family structures; Costanigro et al. (2012), Gschwandtner (2018), Yue et al. (2009); and Wong et al. (2010) are just few of the many studies that show the contribution of individuals' characteristics such income, age, gender, level of education, family structure, employment status, etc as on organic food consumption. The Kantar Wordlpanel dataset used in this study offers a number of household characteristics. These characteristics are not expected to explain the dependent variable (p), and are thus potentially exogenous to the price equation, while being relevant to preferences for organic consumption. We assume in this study that suppliers may not discriminate between individuals across their residual demand, thus consumers are likely to face the same price for the same item. By the same item, we mean the same combination of attributes, which includes chicken part, labels, package, etc., as well as retailer characteristics. However, the non-discriminatory assumption may not hold for some consumer characteristics available in the data, under certain circumstances.

From the dataset, BMI, Pre-family (dummy for young couple with no children), Young-family (dummyfor family with youngest child aged below 5 years old), and Middle-family (dummy for family with youngest child aged between 5 and 9 years old) were tested as potential instruments. The first stage regressions (OLS and probit) are used to test the significance of consumers' characteristics for the choice for organic chicken. Results from the probit first-stage estimation and indicates that the socio-economic characteristics are relevant ($p<0.1$) individually and combined. This is not trivial because the lower the correlation between the instrument and the instrumented variables, the larger is the bias of the IV estimators (thus it would be better to use OLS instead), despite the fact that a large number of observations may offset the effect of a small correlation (Wooldridge, 2010).

These variables, however, should ideally not be correlated with price, as previously explained. A simple correlation test indicates that, among the socio-economic variables, while all significantly correlated with the price, income and age have the highest correlation. Furthermore, when added to the baseline model (OLS), Female, Middle-family, and Older-family dummies are not significant, while Income, Age, Children, BMI (10% confidence), PreFamily (10% confidence), YoungFamily, and Retired are all significant in explaining variations in price. Although this does not prove that the former group of variables are exogenous (as the model includes endogenous variables which would bias the regressors), it is an indication of possible instruments. The results of the instrumental variable tests are presented in section 4.3.

3 Data Description

The paper uses revealed (actual purchase entries) data in a hedonic price model in order to estimate the marginal effect of a list of attributes that determine the price of chicken, with emphasis on the organic attribute. Demand for chicken has increased consistently in the past decades, leading consumers to pay a premium for the characteristics they perceive as beneficial. Using scanned purchase information from UK households collected in 2016 by Kantar Worldpanel, this paper investigates the characteristics of the product, consumers and retailers that might have driven such a strong demand.

3.1 Chicken purchase data

The sample contains 336,970 chicken purchases from 26,658 UK representative households. The paper explores up to 40 variables containing product characteristics (chicken part, price, volume, packing, labelling, etc.), store information (e.g. retailer name, location), and socio-economic characteristics of the households, to investigate the heterogeneity across regions, education level, class, etc. Table 5 shows descriptive statistics. For representativeness, these should be compared to the ones of the usual chicken buyer, rather than the average characteristics of the UK population.

The average age of the household member responsible for the grocery shopping in the sample is 49 years old, 78% of which are female. Households have on average one child, and have an average gross income within category 4 (£30,000 to £39,999 per annum), which was above the national average income in 2016 (£26,300).

Family structure amongst households are fairly distributed, but highest proportion of households (18.6%) are "empty-nest", i.e. 45-65 years old with no children in the household, and the smallest number (10.2%) are "pre-family", i.e. below 45 years old with no children.

Table 5: *Sample socioeconomic description*

Variable	**Mean**	**sd**	**Median**	**Min**	**Max**
Age	49.250	13.680	48	18	95
Female	0.780	0.411	0	0	1
Income	4.210	1.960	5	1	8
Children	0.733	1.006	0	0	7
BMI	26.990	5.700	26	10	66
PreFamily	0.102	0.302	0	0	1
YoungFamily	0.175	0.380	0	0	1
MiddleFamily	0.123	0.328	0	0	1
OlderFamily	0.119	0.324	0	0	1
OlderDependents	0.153	0.360	0	0	1
EmptyNest	0.186	0.389	0	0	1
Retired	0.141	0.348	0	0	1
Scotland	0.075	0.263	0	0	1
Wales	0.046	0.210	0	0	1
North	0.256	0.437	0	0	1
Midlands	0.173	0.378	0	0	1
South	0.247	0.431	0	0	1
East	0.114	0.318	0	0	1
London	0.089	0.285	0	0	1

The regional distribution is as follows: North (25.6%), South (24.7%), Midlands (17.3%), East (11%), London (8.9%), Scotland (7.5%), and Wales (4.6%). Thus, above half of the chicken sold in the country are to attend demand in the North and South regions. Overall, these are similar to the regional population distribution in the UK, but not exactly. However, one should not expect the socio-economic distribution to match the national numbers very precisely, as the data only includes households from the panel that bought chicken at east once in 2016.

4 Regression results and discussion

4.1 Descriptive statistics of he variables used in the regressions

Table 12 shows descriptive statistics for the variables used in equation 8 including the main product characteristics (z) and dummies for promotion, region, and a monthly vector. On average, consumers paid £4.71 per kilogram and bought approximately 1 kg per purchase. Surprisingly, 45.3% of the items were on a type of offer, and 25.2% were budget label (retailer own low value item). Chicken breast is the most popular, forming 48.8% of the observations, and half chicken and wings are the least popular chicken parts. Only 1% of chicken sold was from a brand other than the retailers' own brand, and only 0.2% of entries had a 'healthy' label. Consumption across the months does not vary significantly, but July and August (summer in the UK) seem to be the months with lower chicken consumption, while in winter consumption appears to be relatively higher, with the exception of December, as substitutes (certainly turkey) may be more popular during end of year celebrations.

4.2 Regression Results

Most hedonic price studies involve OLS regressions as discussed. However, due to non-linear nature of the model, OLS leads to a biased and inconsistent estimates of parameters. For this reason two instruments derived from family structures (PreFamily and MiddleFamily) will be used in the 2SLS (used mainly for comparison) and GMM estimations. Their validity is shown in subsection 4.3 below. We use in all models the semi-log function form. Table 13 shows regression results from the OLS, 2SLS, and GMM estimations. The dependent variable is the natural log of the price paid per kilogram of chicken. The R-squared values for the OLS and 2SLS are high (84% and 68%, respectively), which indicates that the regressors are able to explain most variations in the (logged) price of chicken. However, the coefficient of Organic in the 2SLS model is substantially higher than OLS estimates (above five times), raising awareness about the validity of both sets of results. In fact, the organic coefficient in the 2SLS is also substantially higher than the GMM estimates. As explained, GMM estimations are considered the most reliable to effectively address the endogeneity and heteroscesdacity issues encountered in HP estimations. Nonetheless, the only other significant difference between 2SLS and GMM results are with regards to the parameters for "The Black Farmer", with 2SLS reporting a coefficient which is almost 5 times larger than one from the GMM, in absolute terms.

The coefficients in the GMM estimation indicate the change in price, when the attributes increase by one unit. As the model uses the exponential form of the explanatory variables, and the dependent variable is log transformed, the interpretation of the coefficients is straightforward, and represents the marginal effect of the respective variables on price. Therefore, the estimations for the marginal implicit prices were given by: MIP $= \frac{\partial p(z)}{\partial z_i} x \overline{P}$, where $\overline{P}$ is the sample mean price paid per kilogram of chicken (4.70 pounds). The MIPs are presented in the last column of the table.

The GMM estimations show that for the UK consumers the implicit marginal price for organic attribute per kilogram, holding all other factors constant, is £6.36, for freedom food £1.84, for quality £1.59, and halal £0.77. The implicit price consumers pay for a branded chicken product is £0.13 per kilogram, while the budget label gives a discount of £0.48. The coefficient for the 'healthy' variable is not significant in

Table 12: *Descriptive statistics: main attributes*

Variable	Description	Mean	sd	Min	Max
Price	Price/Kg	4.706	2.459	0.100	27.676
LnPrice	Natural log of price/kg	1.412	0.533	-2.303	3.321
Freedom_Food	Freedom food label	0.006	0.077	0	1
Organic	Organic label	0.006	0.074	0	1
Size1	Package weight ¡ 400g	0.117	0.325	0	1
Size2	Weight 400-799g	0.323	0.468	0	1
Size3	Weight 800-1199g	0.223	0.417	0	1
Size4	Weight 1.200g-3000kg	0.334	0.472	0	1
Size5	Package weight > 3kg	0.002	0.049	0	1
Offer	Any type of offer	0.453	0.498	0	1
BudgetLabel	Budget/low cost label	0.252	0.434	0	1
Branded	Not retailer's brand	0.010	0.101	0	1
Quality	Retailer quality label	0.027	0.162	0	1
Healthy	Health label	0.000	0.015	0	1
Halal	Halal chicken	0.002	0.047	0	1
Breast	Part dummy	0.488	0.500	0	1
Drumsticks	Part dummy	0.033	0.179	0	1
Half	Part dummy	0.000	0.015	0	1
Legs	Part dummy	0.040	0.195	0	1
Thigh	Part dummy	0.108	0.310	0	1
Wings	Part dummy	0.015	0.123	0	1
Whole	Part dummy	0.314	0.464	0	1
Jan	Month dummy	0.081	0.273	0	1
Feb	Month dummy	0.083	0.277	0	1
Mar	Month dummy	0.097	0.296	0	1
Apr	Month dummy	0.083	0.276	0	1
May	Month dummy	0.080	0.272	0	1
Jun	Month dummy	0.098	0.297	0	1
Jul	Month dummy	0.074	0.261	0	1
Aug	Month dummy	0.071	0.257	0	1
Sep	Month dummy	0.097	0.297	0	1
Oct	Month dummy	0.078	0.269	0	1
Nov	Month dummy	0.081	0.273	0	1
Dec	Month dummy	0.076	0.264	0	1

Number of Obervations: 336,940

any regression which might seem surprising. Probably this has to do with what this label represents to the consumer and how it is presented and, another, better label it is required to elicit such an important attribute. Chicken breast has an implicit marginal price of £2.38, the highest added value amongst all chicken parts, as expected. The other parts with positive implicit price are half chicken (£1.07) and thigh (£0.39), while all other have negative marginal effect, wings being associated with the lowest marginal implicit price (-£1.54).

The implicit marginal price decreases as package weight increases, smaller packages ($< 400g$) increasing the price by £0.49, and surprising, offers on average only contribute to a decrease of only 9 pence per kilogram of chicken. This indicates that, at least for chicken, retailers use offers as marketing strategy to influence consumers discount *perception* rather than actual price reduction.

Differently from the descriptive section, which show the average price paid for each product characteristics across sellers, the marginal implicit prices show how much individuals would pay for the shopping experience

Table 13: *Regression Results*

LnPrice	OLS		2SLS (IV)		GMM(IV)		MIP
Organic	0.718***	(0.007)	3.748***	(0.000)	1.353***	(0.104)	6.36
Freedom_Food	0.559***	(0.007)	0.626***	(0.000)	0.392***	(0.009)	1.84
Size1	0.350***	(0.013)	0.320***	(0.000)	0.200***	(0.011)	0.94
Size2	0.273***	(0.013)	0.257***	(0.000)	0.177***	(0.011)	0.83
Size3	0.145***	(0.013)	0.133***	(0.000)	0.102***	(0.011)	0.48
Size4	0.019	(0.013)	0.014	(0.000)	-0.014	(0.011)	-0.07
Offer	-0.064***	(0.001)	-0.035***	(0.050)	-0.020***	(0.004)	-0.09
Breast	0.705***	(0.008)	0.715***	(0.000)	0.507***	(0.009)	2.38
Drumsticks	-0.239***	(0.008)	-0.227***	(0.000)	-0.241***	(0.009)	-1.13
Half	0.119***	(0.032)	0.246***	(0.000)	0.227***	(0.027)	1.07
Legs	-0.161***	(0.008)	-0.215***	(0.001)	-0.195***	(0.011)	-0.92
Thigh	0.080***	(0.008)	0.072***	(0.000)	0.074***	(0.009)	0.35
Wings	-0.338***	(0.009)	-0.308***	(0.000)	-0.327***	(0.010)	-1.54
Whole	-0.010	(0.008)	-0.017**	(0.000)	-0.032***	(0.009)	-0.15
Branded	0.054***	(0.006)	0.041***	(0.000)	0.028***	(0.005)	0.13
BudgetLabel	-0.131***	(0.006)	-0.094***	(0.000)	-0.102***	(0.009)	-0.48
Quality	0.389***	(0.005)	0.491***	(0.000)	0.338***	(0.010)	1.59
Halal	0.231***	(0.014)	0.244***	(0.000)	0.164***	(0.011)	0.77
Healthy	0.020	(0.061)	0.051	(0.000)	-0.021	(0.029)	-0.10
Asda	0.046***	(0.002)	0.026***	(0.037)	0.013***	(0.003)	0.06
Aldi	-0.002	(0.006)	-0.047***	(0.000)	-0.013	(0.009)	-0.06
Lidl	0.007	(0.006)	-0.038***	(0.012)	-0.006	(0.009)	-0.03
Iceland	-0.103***	(0.003)	-0.132***	(0.000)	-0.105***	(0.005)	-0.49
Coop	0.160***	(0.003)	0.139***	(0.000)	0.089***	(0.003)	0.42
Costco	0.158***	(0.005)	0.154***	(0.000)	0.135***	(0.004)	0.63
Morrisons	0.115***	(0.002)	0.076***	(0.000)	0.048***	(0.005)	0.23
M_S	-0.066***	(0.007)	-0.230***	(0.000)	-0.130***	(0.016)	-0.61
Ocado	0.156***	(0.006)	0.109***	(0.000)	0.062***	(0.007)	0.29
Sainsburys	0.088***	(0.002)	0.013	(0.000)	0.003	(0.009)	0.01
Tesco	0.040***	(0.002)	0.007	(0.043)	0.001	(0.004)	0.00
TheBlackFarmer	0.290***	(0.013)	-2.675***	(0.000)	-0.580***	(0.097)	-2.73
Waitrose	0.384***	(0.004)	0.184***	(0.000)	0.107***	(0.021)	0.50
Scotland	0.002	(0.002)	-0.013***	(0.000)	-0.011***	(0.003)	-0.05
Wales	-0.016***	(0.002)	-0.013***	(0.000)	-0.008***	(0.002)	-0.04
North	-0.005***	(0.001)	-0.006***	(0.000)	-0.003**	(0.001)	-0.01
Midlands	-0.004***	(0.001)	-0.006***	(0.122)	-0.004***	(0.001)	-0.02
London	-0.007***	(0.002)	-0.033***	(0.000)	-0.025***	(0.004)	-0.12
East	-0.007***	(0.001)	-0.009***	(0.000)	-0.004***	(0.001)	-0.02
Constant	0.897***	(0.015)	0.912***	(0.000)	-0.047***	(0.014)	-0.22
Observations	336,940		336,940		336,940		
R-squared	0.839		0.676				

*Robust standard errors in parentheses, *** $p < 0.01$, ** $p < 0.05$, * $p < 0.1$*
All models include monthly dummies

at that specific supplier, with all other attributes held constant. For example The Black Farmer has the highest average price probably due to its specialization on Organic. Once this is controlled for, it has the lowest marginal implicit price (-£2.73/kg). M&S (-£0.61) and Iceland (-£0.49) are associated with lowest implicit prices and Costco (£0.63) and Waitrose (£0.50) with the highest. Coop (£0.42) and Ocado (£0.29) are in the middle range.

Although statistically significant, there is no large variation in marginal implicit prices across regions, thus price differences in this case are mostly driven by product differentiation. Considering that the South of England is omitted due to collinearity, consumers in the North pay the highest implicit price, followed by the Midlands and East. London has the lowest MIP (-£0.12), whilst consumers in Scotland, with the highest average price (9% above national average), have a MIP of -0.05 (-1%) given all controls. Further heterogeneity is explored in section 4.4.

4.3 Instrumental Variable Tests

Table 14 shows results from statistical tests of the instruments, following the 2SLS and the GMM estimations. The adjusted R2 from the first-stage regression indicates the squared partial correlation between the endogenous regressor and the instruments only, which is usually low. For the endogeneity test of the organic attribute, this study applies the Wu-Hausman and the Durbin-Wu-Hausman, and C Difference-in-Sargan endogeneity test for the 2SLSL and GMM estimations, respectively. With 99% confidence, one can reject the null that Organic is exogenous, thus justifying the use of instrumental variables in the models.

Table 14 shows further the Angrist-pischke F-test for the validity of the instruments. This test shows when one endogeous variable (Organic) is weakly identified in the presence of multiple endogeous variables (which is possible for this study). The test statistic indicates that the instruments are valid, with F-statistics substantially above the threshold of 10 (or 23).

Table 14: *Instruments Validity*

Test	*2SLS*		*GMM*	
Endogeneity				
Durbin-Wu-Hausman x2-test	90.339	***		
Wu-Hausman F-test	90.377	***		
C Difference-in-Sargan			98.520	***
First stage regression				
Adjusted R2	0.088		0.088	
Angrist-Pischke F-statistic	35.663	***	35.663	***
Over-identification				
Wooldridge's robust Test	2.505			
Hansen's J x2-test			2.505	
P-value	0.114		0.280	

*** $p < 0.01$

Table 14 shows Wooldridge's Test for over-identification, given that the IV regression used robust estimations. This is required due to heteroscedasticy, a common problem in hedonic price regressions. The Hansen's J test is the alterntive for the GMM estimation. Over-identification occurs when the number of additional instruments (conditional to at leat one exogenous intrument) exceeds the number of endogenous variables. The test determines if the instruments are uncorrelated with with the error term. A significant test statistic indicates invalid instruments or model misspecification. The results indicate that the instruments pass the test in all models, hence we can reject the null of over-identification, and can conclude that the instruments are valid.

5 Conclusions

This paper has elicited the implicit marginal effect of organic attibute of chicken meat in the UK using an instrumental variable approach in a hedonic pricing setting. The econometric limitations of the hedonic pricing model (HPM) derived from endogeneity issues pose great challenge to researchers and have rarely been addressed. They derive from various sources such as the simultaneous estimation of supply and demand, omitted variables, hedonic sorting or from the nonlinearity of the hedonic price function itself. Rosen (1974) argued in his original article that the attribute of interest in a HPM setting must be treated as endogenous, and the economic source of the endogeneity has been clarified by subsequent authors (see Kahn and Lang 1988 for a summary). And yet, very few studies have tried to address this endogenity empirically.

We address this limitation by instrumenting the organic attribute with two consumer characteristics related to family structure and the age of children.[4] Theoretically, consumer characteristics should be related to organic consumption but not influence the price of organic products. Empirically, the two instruments pass all the validity testes.

We show that when we use instruments, the value of the organic attribute is 2 to 5 times larger than without instruments, depending on the estimation method used (GMM or 2SLS). Because GMM appears to be the more appropriate method in the present case (see Wooldridge 1996) we rely on this estimation and an report an implicit marginal price of 135%, (equivalent to £6.36 per kilogram) for the organic attibute in chicken meat.

One of the main contributions of this paper is to demonstrate how socio-economic consumer characteristics can be used as valid instruments in applications of hedonic price models as they are both central drivers of the demand for the organic attribute and exogenous to the price function. The results show that the organic attribute contributes substantially to the marginal price of chicken across all types of chicken meat.

A reliable estimate of the marginal value of the organic attribute is a necessary first step for an accurate benefit–cost analysis of any policy decision related to organic products. It is especially important when related to meat where animal welfare aspects need to be further considered. And it is especially important at the present time in the UK when in the prospect of Brexit the agricultural policy is in the process of being reformed. To our knowledge, this paper is the first to incorporate an instrumental variable approach in order to isolate the value of the organic attribute for chicken meat in a hedonic pricing setting. We conclude that the organic attribute contributes to the value of chicken meat to a greater extent than previously believed. Our results suggest that the value of policy interventions via support of organic production benefit the UK consumer more than previously estimated. They point out to potential errors in hedonic settings and could have a significant impact on the long-run policy decisions. Measuring the value of the organic attribute without taking into consideration these errors might lead to a severe underestimation of its value to the UK consumer and might lead to misallocation of resources from the policy point of view. Organic production is a resource that generates value through various sources such as perceived better health and taste but also environmentally friendliness and higher animal welfare. Stated preference valuation techniques have been applied to estimate the value of this attribute using models that assume equilibrium market conditions. However, stated preference techniques usually suffer from hypothetical bias. Revealed preference valuation techniques applied to organic food usually involve HPM estimations but do not consider the endogeneity issues. Our analysis suggests that the organic attribute accounts for a much larger portion of chicken meat value than would be presumed if a correction for endogeneity would not have been in place. The economic implications of organic production have received attention from resource economists only relative recently. Organic food products provide a series of benefits to consumers involving their direct use and their value to the environment and the society as a whole, and the present paper suggests a way how these can be estimated more accurately to be better suited for potential policy recommendations.

[4]'PreFamily' (a dummy for a young couple with no children) and 'MiddleFamily' (a dummy for a family with children between 5-9 years old).